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Abstract

AN EXPERIMENTAL STUDY ON THE MECHANICAL STRENGTH OF FUEL CLADDING TUBES UNDER THE LOSS-OF-COOLANT ACCIDENT CONDITIONS OF WATER COOLED REACTORS

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The purpose of this experiment, which has been carried out by a group of specialists under auspices of Japan Atomic Industrial Forum, is to review and confirm the mechanical integrity and behavior of fuel element cladding tubes for light water reactors under the loss-of-coolant accident conditions.

Accumulation, to a certain extent, of fission gases within fuel elements will not affect cladding tubes as the source of internal pressure while the reactor is under operation, since the coolant outside the tubes offsets it as an external pressure. If the coolant pressure drops by such a reason as the loss-of-coolant accident, however, an effective difference between pressures in and out the tubes rises instantaneously, and this may result in bursting. Temperature rise due to the decay heat after the loss-of-coolant causes internal pressure to rise, which may also result in bursting. Evaluation of fuel cladding safety under simulation of such conditions was made by this experiment.

The AISI 304L, 347 stainless steel and Zircaloy-2 tubes were selected for the testing and their diameter-to-thickness ratios were selected between 12.0 and 28.7. Hydrogen absorbed Zircaloy-2 tubes specimens

were also selected for evaluating the effect of hydrogen absorption on the mechanical behavior under the accident conditions.

The experimental conditions were determined from the analysis of the loss-of-coolant accidents for the typical pressurized as well as boiling water reactors. Experiments were performed under the following conditions:

1. Tensile test of the cladding materials at high temperatures up to 700°C, and at the various moderate load rates up to 5.0 $kg/mm^2/sec$.

2. Burst test of the various sized cladding tubes for temperatures ranging from the room temperature up to 700°C.

3. In the dynamic burst test under the various loss-of-coolant accident conditions, the specimens were internally pressurized to the predetermined value at the surface temperatures between 280°C and 450°C and under the external pressure corresponding to the coolant pressure, and then the external pressure was suddenly reduced at the postulated rate for the loss-of-coolant accident.

It is concluded from a series of the above experiments that the mechanical properties of the cladding tubes are scarcely affected by such a load change of postulated pressure decreasing rate at the loss-of-coolant accident, and also it is experimentally confirmed to be possible to estimate the bursting pressure of the fuel cladding tube from the tensile strength of the materials. Less expansion was observed on the Zircaloy-2 tube after bursting which absorbed about 300 ppm hydrogen, though its tensile strength was found to have little changed.